Stability and Scientific Realism

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A sophisticate form of scientific realism claims that one's epistemic commitment should go on those elements of our mature and robust theories which actually play a truly active role in explaining the world. This thesis is supposed to meet the challenge of the pessimistic meta-induction according to which, since theories in the past have been regularly superseded by other theories and this is likely to happen to ours, no realist commitment on current science can be rationally justified. At a first glimpse, the pessimistic meta-induction appears as unquestionable: theories of the past have certainly been replaced by other theories. However, the realist retorts that one does not need to accept theories as an undifferentiated package: "It is enough to show that the theoretical laws and mechanisms which generated the successes of past theories have been retained in our current scientific image" (Psillos 1999, 103). It is those still valid and useful parts of the past theories that capture something of the external reality.

It is clear that this realist program requires a substantial support from history of science. Take, for instance, the concept of "mature theory". According to Anjan Chakravartty, "a mature theory is one that has survived for a significant period of time and has been rigorously tested, perhaps belonging to a discipline whose theories typically make novel predictions" (Chakravartty 2007, 27-28). Only concrete historical analysis can tell us whether the survival period of a theory was significant and whether the tests it passed were rigorous. Analogously, concepts such as "success" or the distinction between idle and effective elements of a theory, both mentioned in Psillos' quote above, become meaningful only in historical perspective. However, the integration of philosophical and historical research is a notorious bone of contention. On the one hand, narratives driven by the necessity of tracing a sequence of successes seem simply bad historiography. On the other, a philosophical program based on historical cases is always exposed to the accusation of descriptivism.

In this paper, I claim that history can significantly help the cause of scientific realism by investigating the strategies used by scientists to "stabilize" their theory, i.e., to produce what philosophers call a mature and successful theory. These strategies include, but are not limited to, the interrelation of a theory with other, already stable, portions of science, the use of more and more severe testing procedures, the generalization and simplification of the formal structure of the theory, and the improvement of the symbolic notation. The common denominator of these strategies is to improve the control on the theory and to distinguish artifacts from genuine information on the world. In this way, the process of theory stabilization produces theoretical claims and scientific practices on which it is rational to place a realist commitment. More importantly, this philosophical perspective can also produce novel and interesting historical narratives. I explore some of these strategies in a concrete historical case, that is the development of perturbation theory in the 18th century and the early treatments of the problem of stability of the solar system. My argument relies on two main points.

First, contrary to the common wisdom, stability was not a object of scientific research from the very beginning, but it emerged as a scientific problem only when perturbation theory reached a level of sophistication that allowed mathematicians to solve it. For Newton, Leibniz, and Euler, the stability of a solar system is no physical and mathematical question. Instead, it is mentioned only as part of a more general theological discourse hinging on the nature of God and the place of man in nature. There is no definition of what gravitational stability means, there is no attempt to lay down conditions of solutions, and, in the physical astronomy of the first half of the 18th century, the stability of the solar system is oftentimes taken for granted. Rather than with global stability, mathematicians since Newton were concerned with more practical local stability issues, i.e., the secular inequalities of the Moon (secular acceleration and precession of the apsides) and of the Jupiter-Saturn system.

However, in the early 1770s, Lagrange, partly supported by Laplace, undertook a program of stabilization of perturbation theory. The methods used by Euler in the late 1740s were too erratic and prone to produce artifacts, such as the strange secular terms. Lagrange wanted to polish perturbation theory of all its imperfections and turn it into a reliable tool for physical astronomy. It was by developing the mathematical practices of perturbation theory that Lagrange, in 1782, eventually posed, and solved, the general problem of the stability of the solar system. His results were extended shortly afterwards by Laplace to the treatment of the two remaining anomalies (the lunar acceleration and the motion of Jupiter and Saturn; the precession of the apsides had been solved by Clairaut in 1749).

Second, in stabilizing perturbation theory, Lagrange and Laplace adopted a variety of strategies. Lagrange’s approach focused on generalizing the theory and thus making it less dependent on procedures tailored for specific problems. His use of the integrals of motion or the so-called Lagrange coordinates are clear examples of this approach. Further, he tried to simplify the formal manipulation of the equations of motion by introducing the perturbing function. Most of these strategies could be regarded as ways of improving the 'robustness' of the theory. On his part, Laplace concentrated on applying perturbation theory to the anomalies of Jupiter and Saturn and the Moon. His way to stabilize the theory was to test it in concrete cases and to develop techniques to find in a faster and more reliable way the sizable terms generating the inequalities. I argue that these methods aimed at making perturbation theory more 'mature' and 'successful'. More importantly, both sets of strategies produced enduring results: the Lagrange coordinates, the perturbing function, the role of resonance in stability, to mention only a few examples, are still part of modern perturbation theory.